THE EFFECT OF ANT SIZE AND TRAP DIAMETER ON *MYRMELEON CRUDELIS* PREY CAPTURE SUCCESS

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Abstract: The outcomes of predator-prey interactions are affected by characteristics of both the predator and the prey. For example, ant lions, their traps, and their arthropod prey all vary in size and could all therefore affect predation rates. In this study, we examined how ant lion trap size and ant prey size combine to affect the overall probability of prey capture. We predicted that ant lions in larger pits would successfully capture both small and large ants, while ant lions in smaller pits would successfully capture only small ants. We placed four species of ants (two large and two small species) into ant lion pits that ranged from small to large and recorded whether the ants escaped or were captured. Our hypothesis and predictions were supported by the data. The likelihood that an ant prey would be captured by an ant lion increased with ant lion pit diameter and overall prey capture probabilities were lower for the larger ants than for the smaller ants.

Key Words: tropical dry forest, predation, ant lion

INTRODUCTION

A predator's foraging success determines its energy gain and survival, as well as the mortality and population dynamics of its prey (Begon et al. 1990). The body size of both predator and prey are important factors in determining the result of their interaction (Osenberg and Mittelbach 1989, Allan et al. 1987). Insects are ubiquitous study subjects that are ideal for examining the relationship between organisms' body sizes and their ability to successfully capture or escape.

Ant lions (*Myrmeleon crudelis*) are small, predatory insects. As flightless larvae, they build pitfall traps for prey capture in loose dry soil. Although ant lions eat a variety of small insects, ants comprise the majority of their diet (Crowley and Linton, 1999). Ant lions are abundant in areas with low rainfall, such as the tropical dry forest of Palo Verde, Costa Rica, where we conducted this study. The ant lion larvae spend up to three years maturing in the soil. As soon as they hatch, the larvae immediately build their first pit. The funnel-shaped pits vary in both diameter and depth. Once an ant or other small arthropod falls into the pit, the ant lion attempts to seize its prey and pull it down into the sand. Previous studies found that the diameter of the ant lion pit is directly related to the size of the larva (McClure 1983, Perlroth et al. 1995).

Thus, we used pit diameter as a surrogate for ant lion size. Finally, previous studies have also shown that the ant lion residents of larger pits are more successful at capturing prey (Gorman and Grabowsky 1991) and that capture time increases with prey size (Guidi 2003).

While several studies have addressed the effects of ant lion size and ant prey size on capture rates independently, no studies have simultaneously tested these two factors. Testing these two factors together is important because the effect of trap and ant lion size on prey capture may depend on prey size. We predicted that pits with larger diameters, and thus larger ant lions, would successfully capture both big and small ant species. Additionally, we predicted that pits with smaller diameters, and thus smaller ant lions, would successfully capture small but not large ant species. However, the effect of pit diameter may be less important when prey are very small. For example, small ants might always be captured regardless of pit diameter.

METHODS

The study took place on 12 and 13 January, 2007 at Palo Verde National Park in the Guanacaste region of Costa Rica. We conducted our study in two disturbed locations: along the field station access road and along the perimeter of the field station buildings. In both locations, pits were found in fine, dry soil. To ensure that our sample pits were representative of the Palo Verde ant lion population, we also measured 132 haphazardly chosen ant lion pit diameters from all over the station.

We chose four species of ants grouped into two size classes: large and small. Using an aspirator, we collected ants from multiple *Acacia collinsii* trees, along the ground, and on building walls. Ten ants from each location were measured, and mean ant lengths determined. Large ants were *Pseudomyrmex spinicola* (mean ± 1 SE: 6.21 ± 0.08 mm) and *P. flavicornis* (5.97 ± 0.15 mm) and small ants were *Crematogaster brevispinosa* (2.83 ± 0.23 mm) and another unknown black ant species (2.24 ± 0.18 mm). We used two species for each size class to ensure that the size effect was actually due to ant size and not differences in ant species.

We placed ten ants of each species into separate ant lion pits. For each, we recorded whether the ant escaped or was captured. An ant was considered captured if it was pulled completely into the hole and disappeared from the surface for at least 15 seconds. An ant was considered escaped if it successfully walked out of the pit. If there was no sign of struggle by the ant, we assumed that the pit was vacant and we discarded that trial. We measured the diameter of each ant lion pit to the nearest 0.01 mm using

calipers. We used an indicator variable multiple logistic regression to test the effects of pit diameter, ant size, and their interaction on the probability of capture with JMP 6.0 (Quinn and Keough 2002).

RESULTS

Large ants were 59% bigger than the small ants (t_{37} = 37.31, P < 0.0001). Additionally, ant species sizes were also significantly different from each other ($F_{3, 35}$= 1172.84, P < 0.001). Ant lion pit diameters were normally distributed for the population sample and for each of the sites. Pit diameters for the population sample and the two study sites combined varied six-fold, ranging from 9.8 mm to 60.6 mm. The mean pit diameter for the two sampling locations and the entire population sample were not significantly different from each other ($F_{4,312}$ = 0.354, P = 0.841).

Ant lion trap diameter and ant prey size both helped to predict prey capture probabilities (χ^2_3 = 55.49, R^2 = 0.31, P < 0.0001). Small ants were captured significantly more often than large ants across all pit diameters, larger pits had higher capture rates, and the effect of pit diameter on capture rate was independent of ant size (Fig. 1, Table 1). For example, in an ant lion pit with a diameter of 15 mm, a large ant had a 30% chance of being captured, whereas a small ant had a 65% chance. At 25 mm, large ants were captured 66% and small ants had a 98% chance. At approximately a 50 mm diameter, large and small ants were captured in 99% and 100% of encounters, respectively (Fig. 1).

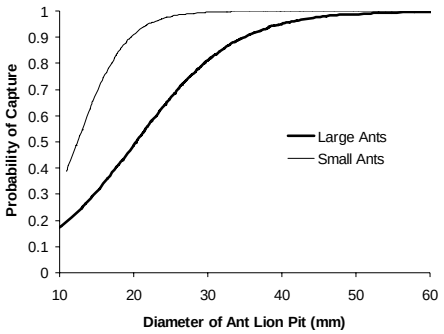

Figure 1. Probability of ant prey capture, based on our ant lion pit diameter and ant prey size according to the model: $g(x) = B_0 + B_1$*diameter + B_2*(size) + B_3*(size*diameter), where g(x) is the probability of being captured, expressed as the natural log of the odds ratio (Quinn and Keough 2002). Large ants were used as the size reference category. The interaction term was not statistically significant (Table 1).

TABLE 1. Model parameters from an indicator variable multiple logistic regression predict prey capture probability.

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-3.4186112	0.9737082	12.33	0.0004
Diameter	0.22761577	0.05419	17.64	<.0001
Size[L]	-1.8611737	0.6998953	7.07	0.0078
(diameter-28.8762)*Size[L]	-0.0766807	0.05419	2.00	0.1571

DISCUSSION

Body size is an important factor in determining the result of predatory interactions (Osenberg and Mittelbach 1989, Allan et al. 1987). Ant lions and ants provide a good system to observe this aspect of predator-prey dynamics because both parties vary in size and interactions between them are easy to manipulate. The likelihood that a prey item will be captured by an ant lion depends both on the size of the ant lion's pit and the size of the prey.

We found that the larger diameter ant lion pits captured prey of both sizes. Specifically, ant lion pits that were greater than approximately 50 mm in diameter could capture even the largest ants used in the study. Although more large ants escaped from smaller pits, smaller ant lions still had significant success at capturing small ant species, suggesting that small and large ant lions have similar success at capturing prey comparable to their own size. Our hypothesis and predictions were supported; larger diameter ant lion pits successfully captured both large and small ants, while smaller diameter ant lion pits successfully captured small ants but fewer large ants. Additionally, the effect of pit diameter on prey capture rates was similar for both small and large ants.

Further experimentation is needed to evaluate the relationship between ant prey species and capture success. Our data cannot definitively demonstrate that size is the only determining factor in capture success. It is likely that some species ant species are more aggressive and naturally more resistant to capture than other species of comparable size. Using a greater number of ant species per size class, future studies could disentangle the effect of ant species (and their associated behaviors) and prey size. While this study used ants 3-7 mm in length, large ground ants in the Palo Verde National Park can be up to 9-10 mm in length *(personal observations).* We also noted that even some of the largest ant lion pits could not capture ants with a mean length equal to or greater than 9.3 mm. Therefore, there may be ant sizes that will always escape, regardless of ant lion size.

Our study takes into consideration a realistic spectrum of ant lion pit sizes, whereas previous studies have grouped ant lion pits into size classes (Goodale et al. 1991). Further studies could use a realistic range of ant lion pits combined with a full spectrum of ant sizes. A greater knowledge of the dynamic relationship between predator and prey characteristics can lead to a

better understanding of interaction outcomes and population dynamics.

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